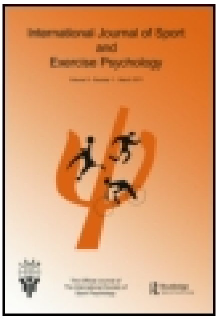


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# Quiet eye training promotes challenge appraisals and aids performance under elevated anxiety

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# Quiet eye training promotes challenge appraisals and aids performance under elevated anxiety

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Quiet eye training, a decision training intervention developed by Vickers and colleagues (see Vickers [Vickers, J.N. 2007. *Perception, cognition and decision training: The quiet eye in action*. Champaign: Human Kinetics] for a review), has been shown to facilitate anxiety-resistant performance in novice learners [Vine, S.J., & Wilson, M.R. 2010. Quiet eye training: Effects on learning and performance under pressure. *Journal of Applied Sport Psychology*, *22*, 361–376; Vine, S.J., & Wilson, M.R. 2011. The influence of quiet eye training and pressure on attention and visuomotor control. *Acta Psychologica*, *136*, 340–346]. However, the potential mechanisms underpinning this beneficial effect are not fully known. This study examined the effects of a quiet eye training intervention on golf putting performance (mean performance error), gaze control (quiet eye duration), and one possible psychological mechanism; cognitive appraisal (evaluation of perceived demands and resources). Thirty novice participants were randomly assigned to a quiet eye or technical trained group and completed 420 baseline, training, retention, and pressure putts. Gaze was measured using an ASL Mobile Eye Tracker. Cognitive anxiety and appraisal were assessed via the mental readiness form-3 [Krane, V. 1994. The mental readiness form as a measure of competitive state anxiety. *The Sport Psychologist*, *8*, 189–202] and cognitive appraisal ratio [Tomaka, J., Blascovich, J., Kelsey, R.M., & Leitten, C.L. 1993. Subjective, physiological, and behavioural effects of threat and challenge appraisal. *Journal of Personality and Social Psychology*, *65*, 248–260], respectively. Although both groups experienced greater cognitive anxiety ($p < .001$), the quiet eye trained group performed more accurately ($p < .001$), displayed more effective gaze control ($p < .001$), and appraised the pressure test more favourably than the technical trained group ($p < .05$). The more positive appraisal arose from the quiet eye trained group reporting a greater perception of coping resources than the technical trained group ($p < .05$). Mediation analyses revealed that cognitive appraisal mediated the relationship between training group and mean radial error during the pressure test. Thus, quiet eye training protects against performance failure under increased anxiety by amplifying perceived coping resources, permitting performers to appraise demanding competitive situations more adaptively, as a challenge rather than a threat.

**Keywords:** cognitive appraisal; challenge; threat; perceived resources; quiet eye

## Introduction

Proficiency-related differences in the gaze strategies underpinning sport-specific decision-making and motor performance have been found for numerous sporting tasks (see Mann, Williams, Ward, & Janelle, 2007 for a meta-analysis and review). One of the seminal studies in this area examined the gaze strategies employed by expert and novice golfers during a golf putting task (Vickers,

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1992). Vickers highlighted key differences in both the preparation and execution phases of the putting stroke. Most notably, experts ensured their gaze was steady on the back of the ball prior to the start of the putting stroke and maintained this fixation during, and momentarily after, the putter contacted the ball. The duration of this fixation, later termed the quiet eye (Vickers, 1996), was a significant determinant of both expertise and proficiency; with experts displaying longer durations than novices and successful putts having longer durations than unsuccessful putts (Vickers, 1992). This finding has since been corroborated; not only in golf putting (Mann, Coombes, Mousseau, & Janelle, 2011; Wilson & Pearcey, 2009), but also across a broad array of targeting, interceptive, and tactical tasks (see Vickers, 2007 for a review).

The quiet eye, generally defined as the final fixation towards a relevant target prior to the initiation of movement (Vickers, 2007), is susceptible to the effects of anxiety. Research has demonstrated that heightened levels of anxiety cause quiet eye durations to shorten and performance to decline (e.g. Behan & Wilson, 2008; Causer, Holmes, Smith, & Williams, 2011; Nibbeling, Oudejans, & Daanen, 2012; Vickers & Williams, 2007). Collectively, this research suggests that anxiety-induced deteriorations in performance may be attenuated by ensuring individuals maintain long and effective quiet eye durations under anxiety-provoking conditions (Wilson, Vine, & Wood, 2009). Recent research has demonstrated that quiet eye training, a decision training intervention that helps individuals understand "where and when" to focus gaze in the time preceding, during, and after the critical movement of a task (Vickers, 2007), can foster anxiety-resistant performance (Vine, Moore, & Wilson, 2011; Vine & Wilson, 2010, 2011). For example, Vine and Wilson (2010) showed that, relative to a technical trained group, a quiet eye trained group maintained longer quiet eye durations and performed a golf putting task more accurately under heightened anxiety. Despite growing evidence regarding the utility of quiet eye training for creating performance that is resilient against the detrimental effects of anxiety, research is needed to identify precisely *how* these interventions provide this benefit (Vine, Moore, & Wilson, 2012).

Whilst recent research has begun to examine possible cognitive neuroscience explanations for the quiet eye phenomenon (e.g. Mann et al., 2011; Moore, Vine, Cooke, Ring, & Wilson, 2012), the potential *psychological* processes underpinning quiet eye training have received scarce attention. To date, only one study has examined the psychological benefits associated with quiet eye training. Wood and Wilson (2012) found that, compared to a practice-only (control) group, a quiet eye trained group reported having greater perceptions of control and performed better in a soccer penalty task under conditions of elevated anxiety. The authors attributed this favourable effect to the structured and repeatable pre-performance routine fostered by quiet eye training (Wood & Wilson, 2012). Indeed, quiet eye training encourages performers to learn a pre-performance routine consisting of a systematic sequence of optimal gaze behaviours that can be employed prior to, during, and after skill execution, and focused upon when experiencing anxiety (Vickers, 2007; Vine et al., 2011; Wilson & Richards, 2011).

Pre-performance routines have been shown to facilitate learning and decrease the likelihood of performance failure under increased anxiety (e.g. Cotterill, 2010; Mesagno & Mullane-Grant, 2010). They have been shown to achieve this, in part, by helping individuals perceive that they have the resources to be able to cope and perform well on a particular task (Hill, Hanton, Matthews, & Fleming, 2010, 2011; Moran, 2009). The importance of such resource appraisals is explicitly considered in a recent model derived from Lazarus's appraisal theory (Lazarus & Folkman, 1984), the biopsychosocial model (BPSM) of challenge and threat (Blascovich, 2008). According to the BPSM, an individual's evaluation of available resources is integral in determining their cognitive appraisal of an anxiety-provoking task and subsequently how they respond. Prior to a self-relevant and meaningful performance task (e.g. exam, speech, sporting competition), individuals evaluate the demands of the task and if they have adequate resources to cope successfully with these demands (Seery, 2011). Individuals who evaluate that they have sufficient resources to meet the demands of the task appraise the task positively, as a challenge, whilst individuals who evaluate that they do not possess the required resources, appraise the task negatively, as a threat (Seery, 2011). Importantly, various studies in psychology have shown that challenge appraisals tend to result in higher levels of performance than threat appraisals (e.g. Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004; Moore, Vine, Wilson, & Freeman, 2012).

This study aimed to investigate whether quiet eye training might benefit performance in anxiety-provoking environments by providing a structured, step-by-step, pre-performance routine that, by modelling expert-like gaze behaviour, enhances perceptions of coping resources and promotes challenge appraisals. In order to achieve this, this study analysed a subset of self-report data collected alongside data regarding the kinematic and psychophysiological changes accompanying quiet eye training which has been published previously (see Moore, Vine, Cooke, et al., 2012). We hypothesised that both quiet eye and technical trained groups would experience greater cognitive anxiety and evaluate a pressure test as more demanding than retention tests. Furthermore, we hypothesised that the quiet eye trained group would outperform those in the technical trained group in a pressure test, and display more effective gaze control (i.e. longer quiet eye durations) as well as report a more favourable demand–resource evaluation of the pressure test task (i.e. greater perceived resources and challenge appraisals). Finally, to explore the role of cognitive appraisal and its components (perceived demands and resources) in mediating the effects of quiet eye training on performance under heightened anxiety, mediation analyses were conducted (Hayes & Preacher, submitted). It was predicted that cognitive appraisal, and specifically perceived resources, would mediate the relationship between training group and performance during the pressure test.

## Method

### *Participants*

The kinematic and psychophysiological consequences of quiet eye training were examined using a sample consisting of 40 undergraduate students (Moore, Vine, Cooke, et al., 2012). This study analysed a subset of data collected from 30 of these participants (mean age, 19.73, SD = 1.82), as these had completed all the necessary self-report measures. All participants who volunteered to take part were tested individually and were right-handed novice golfers with normal or corrected vision. The study protocol received ethical approval and each participant provided written informed consent.

### *Measures*

*Cognitive anxiety*. The cognitive subscale from the Mental Readiness Form-3 (MRF-3; Krane, 1994) was employed to assess cognitive state anxiety. This scale is anchored between *not worried* (=1) and *worried* (=11).

*Cognitive appraisal*. The cognitive appraisal ratio (Tomaka, Blascovich, Kelsey, & Leitten, 1993) was used to measure cognitive appraisal. Perceived demands were assessed by asking "How demanding do you expect the golf putting task to be?", whilst perceived resources were assessed by asking "How able are you to cope with the demands of the golf putting task?". These two items were rated using a six-point Likert scale anchored between *not at all* (=1) and *extremely* (=6). Perceived demands were then divided by perceived resources to provide a ratio score, with a score greater than 1 reflecting a threat appraisal and a score less than 1 reflecting a challenge appraisal. This self-report measure has been widely used in the cognitive appraisal literature (e.g. Feinberg & Aiello, 2010; Moore, Vine, Wilson, et al., 2012).

*Performance*. Mean performance error (the average distance the ball finished from the hole in centimetres) was recorded as a measure of task performance. Performance error was measured after each trial by the experimenter using a standard tape measure. An average was calculated for each participant during each test by dividing the total radial error by the number of trials completed. For trials where the putt was holed, the experimenter recorded zero, and employed zero in the calculation of mean performance error (as Cooke, Kavussanu, McIntyre, & Ring, 2010).

*Quiet eye duration*. Gaze was measured using an Applied Science Laboratories (ASL; Bedford, MA, USA) Mobile Eye Tracker (see Moore, Vine, Cooke, et al., 2012 for a detailed description of how the ASL Mobile Eye Tracker records gaze). The quiet eye duration was operationally defined as the final fixation towards the ball prior to the initiation of the backswing (Vickers, 2007). A fixation was defined as a gaze maintained on the ball within 1° of visual angle for a minimum of 100 ms or 3 frames (Wilson & Pearcey, 2009; Wilson et al., 2009). The quiet eye onset occurred prior to the backswing and the quiet eye offset eventuated when the gaze deviated off the fixated object by 1° or more, for greater than 100 ms (Vickers, 2007). Gaze data was analysed using Quiet Eye Solutions software (www.QuietEyeSolutions.com). This software allows for frame-by-frame coding of both the motor action (recorded from the Mobile Eye's scene camera at 30 Hz) and the gaze of the performer, and automatically calculates quiet eye duration. Congruent with previous research (e.g. Vine & Wilson, 2010), a subset of putts was selected for frame-by-frame video analysis (a total of 600 putts); every fourth for pre-test and every second for test phases (a total of 10 putts per test). The researcher was blind to the test and status (group) of each participant when analysing the data. A second analyst blindly scored 12.5% of the data, and the inter-rater reliability coefficient, calculated using the interobserver agreement method (Thomas & Nelson, 2001), was satisfactory at 91% (Vine & Wilson, 2011).

### *Procedure*

All participants were required to attend five one-hour sessions over a period of seven days. On day 1 (session 1), participants were introduced to the task which required the participants to perform straight putts from three 3.05 m locations to a regulation hole (diameter = 10.80 cm) on an artificial putting green (length = 6 m, width = 2.5 m; Stimpmeter reading = 3.28 m). All participants were informed that they would use the same standard length (90 cm) blade style golf putter (Sedona 2, Ping, Phoenix, AZ) and regular-size (diameter = 4.27 cm) white golf balls for the duration of the study. Participants then provided informed consent, before being fitted with the eye-tracker, which was then calibrated. Calibration was checked for accuracy after every 10 putts.

Next, participants received generic instructions relating to the task. They then completed the cognitive appraisal ratio prior to completing a block of 40 putts. Performance and gaze data were continuously recorded throughout these putts. This data acted as a baseline (pre-test) measure. Participants then began their respective training regime (quiet eye or technical; see Training Protocol), and completed two blocks of 40 putts. The experimenter reiterated the training points to participants prior to each block of 40 putts. The participants then completed three blocks of 40 putts on days 2 and 3 (sessions 2 and 3), to complete a total of 320 training putts (8 blocks of 40 putts). The number of training putts performed is consistent with previous training studies for self-paced motor skills in novices (e.g. Vine & Wilson, 2010, 2011).

On day 5 (session 4), participants were once again fitted with the eye-tracker which was calibrated. The participants then completed a retention test comprising a single block of 20 putts, prior to which participants received no training instructions. On day 7 (session 5), participants received instructions from the experimenter aimed at manipulating their levels of anxiety (see Anxiety Manipulation), before completing 20 competition putts in a pressure test. Finally, participants completed a second retention test (identical to retention 1) to form an A-B-A (retention-pressure-retention) design (Vine & Wilson, 2010). The cognitive appraisal ratio and MRF-3 were completed prior to each test, whilst performance and gaze data were recorded continuously throughout each test. Finally, participants were thanked and debriefed.

### *Training protocol*

Participants were randomly assigned to either a quiet eye or technical trained group. The technical trained group received six technical coaching points related to the mechanics of their putting stroke (Pelz, 2000), whilst the quiet eye trained group underwent a putting decision training regime (see Vickers, 2007; Vine & Wilson, 2010). First, the quiet eye trained group viewed a video of an elite golfer displaying the optimal quiet eye and gaze control for golf putting. The researcher pointed out the key features of the elite golfer's gaze control to the quiet eye trained participants and asked questions to aid their understanding. Second, the researcher showed the quiet eye trained group a video of their own gaze control and asked them to note any differences between their gaze control and that of the elite golfer. Finally, the quiet eye trained group received six specific quiet eye training points that would allow them to mimic the gaze control of the elite golfer. These were coupled to reflect similar phases of the putt as the technical instructions (i.e. preparation, aiming, putter-ball alignment, putting stroke, post-contact) to minimise differences in the focus and timing of instructions (see Appendix 1 and Moore, Vine, Cooke, et al., 2012).

### *Anxiety manipulation*

Several techniques were used prior to the pressure test to create social comparison and evaluative threat (Baumeister & Showers, 1986), as these have effectively increased cognitive anxiety in similar studies (e.g. Vine & Wilson, 2010, 2011). First, participants were instructed that there was a competition and that the best performing individual would receive a prize of £50. Second, participants were informed that their performance would be contrasted with others taking part and may be included in a presentation to their fellow students. Finally, participants were informed that, based on other participant's performance to date, their performance during the previous 20 putts (retention test 1) placed them in the bottom 30%. They were asked to try and improve upon this performance otherwise their data would be of no use for the study.

### *Statistical analysis*

A series of dependent *t*-tests revealed no differences between retention tests 1 and 2 in terms of cognitive anxiety, mean performance error, and quiet eye duration for either group. Therefore, the retention test data for these measures were aggregated to simplify the presentation and discussion of the results. However, these analyses did reveal a significant difference in the cognitive appraisal reported by the technical trained group at retention tests 1 and 2. Subsequently, cognitive appraisal data (including perceived demands and resources) were all subject to 2 (Group) × 4 (Test) mixed design analysis of variances (ANOVAs), whereas the mean performance error and quiet eye duration data were each subjected to a 2 (Group) × 3 (Test) mixed design ANOVA. Furthermore, the cognitive anxiety data was subject to a 2 (Group) × 2 (Test) mixed design ANOVA.

Significant main and interaction effects were followed up with least significant difference (LSD) post-hoc *t*-tests. In all ANOVAs in which the sphericity assumption was violated, the degrees of freedom were corrected using the Greenhouse-Geisser correction procedure. For these ANOVA results the uncorrected degrees of freedom are reported along with the corrected probability values and the epsilon value ($\acute{\varepsilon}$). Effect sizes were calculated for all ANOVA results using partial eta squared ($\eta_p^2$) for omnibus comparisons.

Finally, to determine if significant changes in cognitive appraisal, perceived demands, and/or perceived resources mediated any between-group differences in performance during the pressure test, mediation analyses were performed using the MEDIATE SPSS custom dialog developed by Hayes and Preacher (Hayes & Preacher, submitted). This custom dialog tests the total, direct, and indirect effects of an independent variable on a dependent variable through a proposed mediator and allows inferences regarding indirect effects using percentile bootstrap confidence intervals.



## Results

### *Anxiety manipulation check*

The 2 (Group) × 2 (Test) ANOVA revealed a significant main effect for Test, $F(1, 28) = 57.76$, $p < .001$, $\eta_p^2 = .67$, both the quiet eye trained (pressure $M = 5.53$, SD = 1.41; retention $M = 2.93$, SD = 1.16) and technical trained (pressure $M = 6.13$, SD = 1.51; retention $M = 3.67$, SD = 1.59) groups reported experiencing greater cognitive anxiety during the pressure test than the retention tests ($p < .001$). There was no significant main effect for Group, $F(1, 28) = 2.78$, $p = .11$, $\eta_p^2 = .09$, and no significant interaction effect, $F(1, 28) = 0.04$, $p = .84$, $\eta_p^2 = .00$, indicating that both groups had comparable levels of cognitive anxiety across tests. The results therefore support the effectiveness of our anxiety manipulation.

### *Quiet eye duration and performance (mean performance error)*

The 2 (Group) × 3 (Test) ANOVAs yielded significant Group main effects for both quiet eye duration, $F(1, 28) = 39.54$, $p < .001$, $\eta_p^2 = .59$, and mean performance error, $F(1, 28) = 8.64$, $p < .01$, $\eta_p^2 = .24$. There were also significant Test main effects for quiet eye duration, $F(2, 56) = 114.38$, $p < .001$, $\acute{\varepsilon} = .66$, $\eta_p^2 = .80$, and mean performance error, $F(2, 56) = 90.93$, $p < .001$, $\acute{\varepsilon} = .67$, $\eta_p^2 = .77$. Furthermore, there were significant interaction effects for quiet eye duration, $F(2, 56) = 43.56$, $p < .001$, $\acute{\varepsilon} = .66$, $\eta_p^2 = .61$, and mean performance error, $F(2, 56) = 8.95$, $p < .001$, $\acute{\varepsilon} = .67$, $\eta_p^2 = .24$. Follow-up *t*-tests revealed no differences between the groups in either measure at pre-test (both *p*s >.69); however, the quiet eye trained group displayed longer quiet eye durations and lower mean performance error than the technical trained group during the retention and pressure tests (all *p*s <.05). Within-group analyses revealed that both groups experienced improvements in quiet eye duration (longer) and mean performance error (lower) between pre-test and retention tests (all *p*s <.001). However, while the quiet eye trained group displayed no change in quiet eye duration ($p = .33$) and lower mean performance error in the pressure test relative to the retention tests ($p < .05$), the technical trained group displayed shorter quiet eye durations and higher mean performance error in the pressure test than the retention tests (both *p*s <.05). The quiet eye duration and mean performance error data are presented in Figures 1 and 2, respectively.

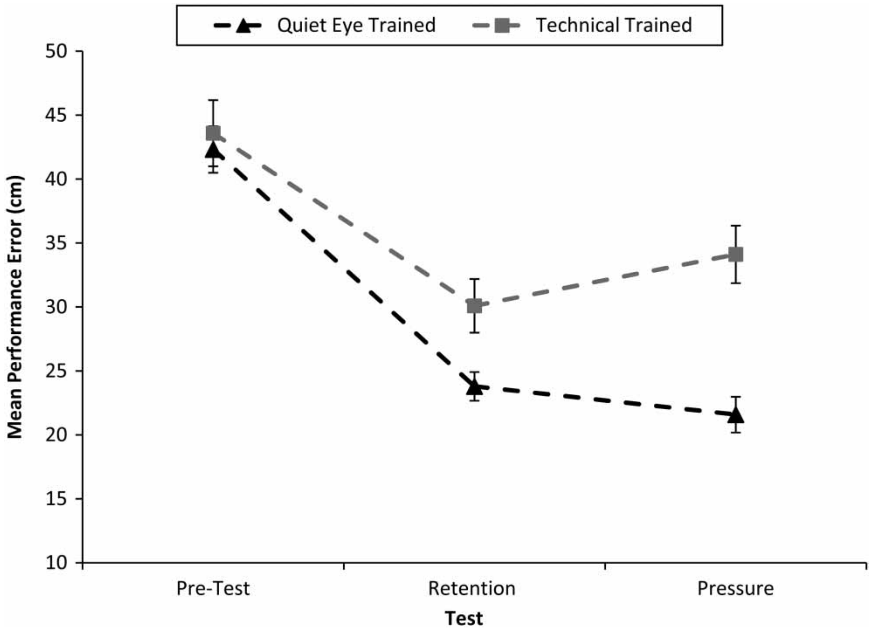


Figure 1. Mean (SE) performance error (cm) for the quiet eye and technical trained groups during pre-test, retention test, and pressure test.

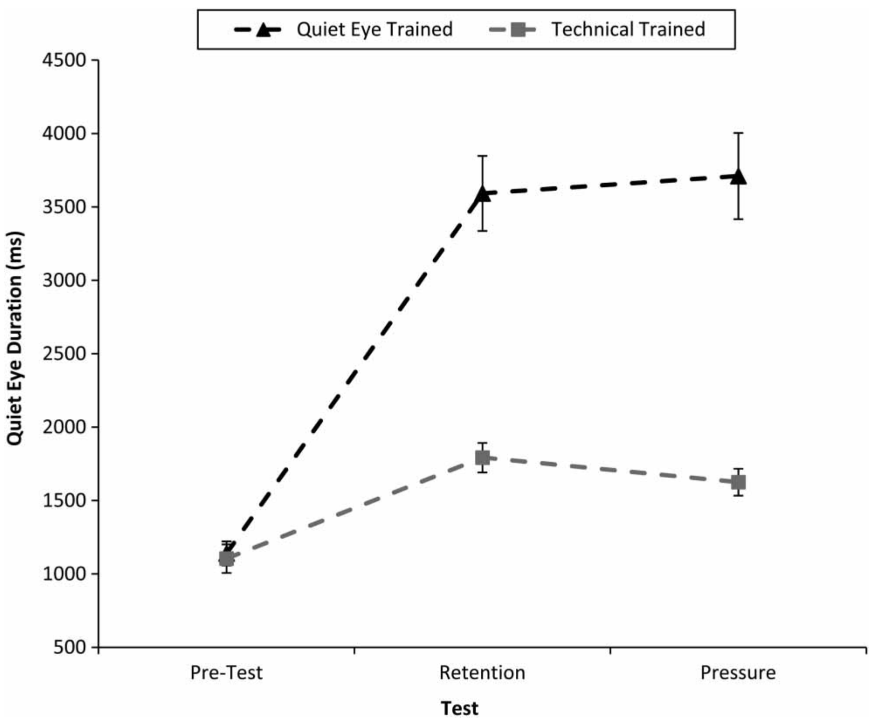


Figure 2. Mean (SE) quiet eye duration (ms) for the quiet eye and technical trained groups during pre-test, retention test, and pressure test.

### *Cognitive appraisal*

The 2 (Group) × 4 (Test) ANOVA yielded no significant Group main effect for the cognitive appraisal ratio, $F(1, 28) = 3.26$, $p = .08$, $\eta_p^2 = .10$, however, there was a significant Test main effect, $F(3, 84) = 20.26$, $p < .001$, $\acute{\varepsilon} = .82$, $\eta_p^2 = .42$, and a significant interaction effect, $F(3, 84) = 3.20$, $p < .05$, $\acute{\varepsilon} = .82$, $\eta_p^2 = .10$. Follow-up *t*-tests revealed no differences between the groups at pre-test and retention test 1 (both *p*s >.16), however, the quiet eye trained group reported a lower ratio score (indicating greater challenge) than the technical trained group during retention test 2 and the pressure test (both *p*s <.05). Within-group analyses revealed that whilst the quiet eye trained group reported a lower ratio score at retention test 1 than at pre-test ($p < .01$), the technical trained group reported no change ($p = .22$). Furthermore, both groups reported an increase in ratio score (indicating greater threat) between both retention tests and the pressure test (all *p*s <.005). However, whilst the quiet eye trained group evaluated the pressure test as a challenge ($M = 0.77$, SD = 0.37), the technical trained group evaluated the pressure test as a threat ($M = 1.11$, SD = 0.49). The cognitive appraisal data are presented in Table 1.

To examine which specific element of cognitive appraisal was influenced by quiet eye training, separate 2 (Group) × 4 (Test) ANOVAs were run on perceived demands and resources. There was no significant Group main effect for perceived demands, $F(1, 28) = 0.62$, $p = .44$, $\eta_p^2 = .02$, but a significant Group main effect for perceived resources was found, $F(1, 28) = 8.47$, $p < .01$, $\eta_p^2 = .23$. There were also significant Test main effects for both perceived demands, $F(3, 84) = 20.13$, $p < .001$, $\eta_p^2 = .42$, and perceived resources, $F(3, 84) = 3.63$, $p < .05$, $\eta_p^2 = .12$. There was no significant interaction effect for perceived demands, $F(2, 56) = 2.87$, $p = .07$, $\eta_p^2 = .09$, but there was a significant interaction effect for perceived resources, $F(3, 84) = 3.11$, $p < .05$, $\eta_p^2 = .10$. Follow-up within-group analyses on the Test main effect for perceived demands revealed that both groups perceived the pressure test as more demanding than the retention tests (both *p*s <.001).

Follow-up analyses on the significant interaction effect for perceived resources revealed no between-group differences at pre-test ($p = 1$), however, the quiet eye trained group reported having greater resources than the technical trained group during retention and pressure tests (all *p*s <.05). Furthermore, follow-up within-group analyses revealed that the quiet eye trained group experienced an increase in perceived resources between pre-test and retention test 1 ($p < .005$), but no change in perceived resources between retention and pressure tests (both *p*s $> .10$). In contrast, the technical trained group reported no change in perceived resources between pre-test and retention test 1 ($p = .84$) or retention test 1 and pressure test ($p = .27$), but a decrease in perceived resources between retention test 2 and the pressure test ($p < .05$). The perceived demands and resources data are presented in Table 1.

### *Mediation analyses*

To test if the effect of training group on pressure test performance was mediated through the appraisal measures, training group was entered as the independent variable, mean performance error was entered as the dependent variable, and cognitive appraisal, perceived demands, and perceived resources were entered separately as potential mediators. Based on a 10,000 sampling rate, the results from bootstrapping revealed a significant indirect effect for cognitive appraisal, 95% CI −6.66 to −0.41, but not perceived demands, 95% CI −5.26 to 2.03, or perceived resources, 95% CI −5.04 to 1.09. Thus, only cognitive appraisal mediated the relationship between training group and mean performance error during the pressure test.

Table 1. Mean (SD) perceived demands (1–6), perceived resources (1–6), and cognitive appraisal ratio scores (0.16–6) for quiet eye and technical trained groups during pre-test, retention tests, and pressure test.

| | Pre-test | | Retention 1 | | Pressure | | Retention 2 | |
|---|---|---|---|---|---|---|---|---|
| | Quiet eye | Technical | Quiet eye | Technical | Quiet eye | Technical | Quiet eye | Technical |
| Perceived demands (1–6) | 2.33 (1.05) | 2.27 (1.10) | 2.07 (0.70) | 2.06 (1.03) | 2.93 (0.88) | 3.27 (1.04) | 1.80 (0.68) | 2.47 (1.06) |
| Perceived resources (1–6) | 3.67 (0.98) | 3.67 (1.18) | 4.53 (0.74)** | 3.60 (0.83) | 4.13* (0.83) | 3.27 (0.96) | 4.67** (0.98) | 3.67 (0.72) |
| Cognitive appraisal ratio (0.16–6) | 0.70 (0.41) | 0.70 (0.44) | 0.45 (0.22) | 0.59 (0.34) | 0.77* (0.37) | 1.11 (0.49) | 0.41** (0.19) | 0.71 (0.36) |

Note: Significantly different from the technical trained group, $*p < .05$, $**p < .01$.

## Discussion

Effective motor skill training programmes must not only help performers learn skills as quickly and efficiently as possible, but also ensure skills are robust over time and resilient to the specific demands inherent in the performance environment. Despite increasing evidence regarding the efficacy of a decision training intervention, quiet eye training, for facilitating skill acquisition that is resilient to anxiety-induced performance degradation (e.g. Vine & Wilson, 2010, 2011), the mechanisms underpinning this beneficial effect are unclear. This study aimed to shed some light on this issue.

### *Quiet eye and performance*

There were no differences in quiet eye duration and performance (mean performance error) between the groups at pre-test. Both groups displayed increases in quiet eye duration and decreases in performance error from pre-test to retention tests. However, the quiet eye trained participants displayed longer quiet eye durations and lower performance error relative to their technical trained group counterparts during retention and pressure tests (see Figures 1 and 2). Thus, the results offer further support for the utility of quiet eye training for accelerating learning and protecting performance under anxiety-provoking conditions. Interestingly, however, our previous examination of potential explanations for the performance benefit apparent under increased anxiety found that no kinematic or psychophysiological variables (changes in heart rate and muscle activity) mediated this between-group difference in performance (see Moore, Vine, Cooke, et al., 2012 for a detailed discussion of these results). This article therefore explored a potential *psychological* explanation for this clear performance advantage under elevated anxiety; cognitive appraisal.

### *Cognitive appraisal*

There were no differences in cognitive appraisal between the groups at pre-test or during the first retention test. However, the quiet eye trained group reported a lower ratio score than the technical trained group during the second retention test. Moreover, while the quiet eye trained group reported a lower ratio score during retention test 1 compared to pre-test, the technical trained group reported no change in ratio score (see Table 1). Thus, the quiet eye trained group appraised the golf putting task at retention as more of a challenge and less of a threat compared to the technical trained group.

Although both groups reported a higher ratio score during the pressure test than the retention tests, the quiet eye trained group appraised the pressure test as a challenge (ratio <1), whilst the technical trained group appraised the pressure test as a threat (ratio >1; see Table 1). Mediation analyses revealed that cognitive appraisal mediated the effect of training group on pressure test performance, implicating cognitive appraisal as a psychological process through which quiet eye training might aid performance under increased anxiety. Quiet eye training appeared to facilitate anxiety-resistant performance by encouraging performers to appraise anxiety-provoking competition more favourably, as a challenge rather than a threat. Collectively, these findings support previous research, demonstrating that challenge appraisals are associated with better performance than threat appraisals. For example, Blascovich and colleagues demonstrated that baseball and softball players who appraised a three minute sport-relevant speech prior to the start of the season as a challenge, performed better during the subsequent season than players who appraised the speech as a threat (Blascovich et al., 2004). Similar results have also been reported for academic (e.g. Seery, Weisbuch, Hetenyi, & Blascovich, 2010), cognitive (e.g. Mendes, Blascovich, Hunter, Lickel, & Jost, 2007), and motor (e.g. Moore, Vine, Wilson, et al., 2012) task performance.

An analysis of the perceived demand and resource appraisals comprising the cognitive appraisal ratio can further explain *how* quiet eye training led participants to make challenge appraisals. There were no between-group differences in perceived demands at pre-test or during the retention tests, and no differences in perceived resources at pre-test. However, the quiet eye trained group reported having greater resources than the technical trained group during the retention tests. Moreover, while the quiet eye trained group reported an increase in resources between pre-test and the first retention test, the technical trained group displayed no change (see Table 1). Thus, quiet eye training enhanced perceptions of resources, leading quiet eye trained participants to appraise the golf putting task at retention as more of a challenge and less of a threat relative to their technical trained counterparts.

Both groups perceived the pressure test as more demanding than the retention tests. There were no differences between the groups in terms of perceived demands during the pressure test (see Table 1). Thus, unsurprisingly, perceived demands did not mediate the effect of training group on performance during the pressure test. However, the quiet eye trained group reported having greater resources than the technical trained group during the pressure test. Indeed, the quiet eye trained group reported no change in resources from either retention test to pressure test, while the technical trained group reported no change from the first retention test to pressure test, but a decrease in resources from the second retention test to pressure test (see Table 1). Therefore, quiet eye training led participants to appraise the pressure test as a challenge by maintaining their perception that they possessed the resources to cope with the demands of the competitive golf putting task. In contrast, the technical trained group appraised the pressure test as a threat because they perceived that they lacked the required resources to cope with the demands of the task. However, in contrast to predictions, mediation analyses revealed that perceived resources did not mediate the effect of training group on pressure test performance. Thus, although differences in perceived coping resources led to divergent appraisals of the competitive golf putting task, these differences did not account for the superior performance displayed by the quiet eye trained group relative to the technical trained group during the pressure test. This suggests that quiet eye training aids performance under elevated anxiety by positively influencing the *balance* of demand and resource evaluations rather than by only increasing perceived coping resources.

### *Applied implications, limitations, and future directions*

Quiet eye training facilitated anxiety-resistant performance by promoting challenge appraisals through enhancing perceptions of coping resources. Skill acquisition specialists and sport psychologists interested in optimizing the learning of skills, so they are robust under conditions of elevated anxiety, are therefore encouraged to employ quiet eye training techniques. However, it is important that researchers determine whether cognitive appraisal is a psychological mechanism unique to quiet eye training or whether it is a potential mechanism through which all pre-performance routines aid performance in anxiety-provoking conditions. Furthermore, it is necessary for future research to examine this and other potential mechanisms in expert/intermediate level performers.

The theory of challenge and threat states in athletes (TCTSA; Jones, Meijen, McCarthy, & Sheffield, 2009), a recent theory applying the propositions of the BPSM (Blascovich, 2008) to sport, proposes that resource appraisals are influenced by perceptions of control, self-efficacy, and achievement goals. Higher perceptions of control, higher self-efficacy, and a focus on approach goals are predicted to result in higher perceptions of resources and challenge appraisals (Jones et al., 2009). We postulate that by fostering a pre-performance routine that encourages individuals to focus on using appropriate gaze—something that is within their control—quiet eye training may support the accretion of coping resources by promoting increased perceptions of control and subsequent challenge appraisals. Indeed, Wood and Wilson (2012) demonstrated that quiet eye training benefitted performance under conditions of increased anxiety by enhancing perceptions of control. However, as this study did not directly measure perceptions of control, future research should employ direct measures of perceived control and other antecedents of challenge and threat appraisals to identify precisely *how* quiet eye training enhances perceived coping resources and promotes challenge appraisals. The TCTSA also makes predictions regarding the consequences of challenge and threat appraisals (see Jones et al., 2009), and whilst these were not examined in this study, researchers are encouraged to examine these propositions and fully test this model.

The BPSM (Blascovich, 2008) specifies that demand and resource appraisals are influenced by a wide variety of factors (e.g. danger, uncertainty, novelty, etc.) as well as elements of the motivated performance task itself such as task difficulty (Seery, 2011). Quiet eye training has been proposed to simplify the task by reducing the degrees of freedom individuals attempt to control during task-performance (Harle & Vickers, 2001). Indeed, in this study, whilst the technical trained individuals had to try and exercise control over their head, legs, arms, and shoulders during the golf putting task, the quiet eye trained individuals only had to attempt to exert control over their gaze (see instructions in Appendix 1). Therefore, we suggest that quiet eye training might heighten perceptions of coping resources and promote challenge appraisals under increased anxiety by reducing the degrees of freedom individuals have to try and control, hence lowering the perceived difficulty of the task. Future research is also encouraged to examine this as a possible explanation for *how* quiet eye training increases perceived coping resources and facilitates challenge appraisals.

Although the results from this study are interesting, it is not without its limitations. Firstly, although widely used, several authors have criticised self-report measures of challenge and threat appraisals as employed in the present study (e.g. Blascovich et al., 2004). Therefore, investigators are encouraged to adopt objective cardiovascular measures of these appraisals in future research examining this psychological process (see Moore, Vine, Wilson, et al., 2012, for a recent example). Indeed, while both appraisals are associated with increases in heart rate and decreases in cardiac pre-ejection period, challenge appraisals are indexed by higher cardiac output and lower total peripheral resistance relative to threat appraisals (Seery, 2011). Unfortunately, these cardiovascular markers were not estimated in this study.

Secondly, the amount of instruction and "input" provided to the quiet eye and technical trained groups differed, as the technical trained group did not view or receive feedback relating to their own gaze or that of an elite golfer. This extra instruction may have led the quiet eye trained group to feel more confident and motivated to perform well. Thus, to control for any possible motivational confounding effects, future research should ensure that quiet eye trained and other experimental groups are matched in terms of the quantity and quality of instructions they receive. Finally, consistent with previous quiet eye training research (e.g. Vine & Wilson, 2010), this study assessed the benefits of quiet eye training in terms of performance accuracy (mean performance error). However, recent research has also found a link between longer quiet eye durations and greater performance consistency, in terms of bivariate error (e.g. Rienhoff, Baker, Fischer, Strauss, & Schorer, 2012). Thus, future research should examine whether the beneficial effects of quiet eye training transcend both performance accuracy and performance consistency.

## Conclusions

To conclude, this study investigated a possible psychological mechanism through which quiet eye training might aid performance under increased anxiety; cognitive appraisal. Our results add to increasing evidence regarding the utility of quiet eye training for facilitating the acquisition of skills that are resilient to the negative effects of anxiety. During the pressure test, despite both groups experiencing greater cognitive anxiety and evaluating the pressure test as more demanding than the retention tests, the quiet eye trained group outperformed the technical trained group. The quiet eye trained group maintained optimal gaze control (longer quiet eye durations), reported greater perceived coping resources, and appraised the pressure test as a challenge, whilst the technical trained group displayed disrupted gaze control (shorter quiet eye durations), reported fewer perceived coping resources, and appraised the pressure test as a threat. Mediation analyses confirmed that cognitive appraisal mediated the relationship between training group and pressure test performance. Thus, quiet eye training facilitated anxiety-resistant performance by encouraging performers to appraise anxiety-provoking competition as a challenge rather than a threat. We propose that by providing participants with a pre-performance routine to utilise prior to, during, and after movement execution, and focus upon when experiencing anxiety, quiet eye training enhances perceptions of coping resources and promotes challenge appraisals by increasing perceived control and/or reducing the perceived difficulty of the task. However, future research is needed to examine these predictions and extend our knowledge regarding this underlying psychological mechanism.


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**Appendix 1. Training instructions given to the quiet eye and technical trained groups during the training phase.**

| Quiet eye training instructions | Technical training instructions |
|---|---|
| 1. Assume your stance and ensure your gaze is located on the back of the ball. | 1. Take your stance with your legs shoulder width apart. |
| 2. After setting up over the ball, fix your gaze on the hole. | 2. Set your position so that your head is directly above the ball looking down. |
| 3. Make no more than three fixations towards the hole. | 3. Keep your clubhead square to the ball. |
| 4. Your final fixation should be a quiet eye on the back of the ball. The onset of the quiet eye should occur before the stroke begins and last for two to three seconds. | 4. Allow your arms and shoulders to remain loose. |
| 5. Ensure you direct no gaze to the clubhead during the putting stroke. | 5. The putting action should be pendulum like, making sure that you accelerate through the ball. |
| 6. The quiet eye should remain on the green for 200 to 300 ms after the club contacts the ball. | 6. After contact follow through but keep your head still and facing down. |